Planetary Surface Scenario

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Time Windows-Initial

- Early-Expedition
  - –1st 5 Years of Human Exploration
    - Crews of 6-12
      - –Limited habitat
        - »Limited stay

Time Windows-Intermediate

- Advanced exploration-Base
  - –Next 10-20 Years of Human Exploration
    - Crews of 10-20 growing to perhaps 100
      - –Infrastructure established
      - –Multiple field trips from logistic base (Winnebago)

Time Windows-advanced

- Advanced exploration-Base
  - –Next 40 Years of Human Exploration
    - Crews of 100+
      - –Permanent base
        - »Multiple field camps
        - »Depot for fuel, food, supplies
        - »Extensive science lab at base
        - »Initial tourism

Permanent residents on Mars

Goals and Objectives

- Initially Science-driven
  Search for life and prebiology organics
  Geologic/biologic/organics field mapping
  Culturing microbes and genetic mapping in laboratory
  Screening of samples for return to Earth

- Evolution to permanent base
  Long term geologic and biologic mapping
  "Living off the land" development and evolution
  Establishment of permanent society
  Economic/societal implications and goals

Role of robots (initial time window)

Robotic base preparation

Science observers and sensor interaction

Assistants for human EVAs

Assistants for base support

Assistants for sample management and control

Assistants for sample analysis

Role of robots (initial time window)

Proceeding list plus attention to:

Human-centered computing applications (general robot/human interactions)

Projected existence (appropriate mix between teleoperation and autonomous robotics)

Role of robots (intermediate time window)

Previous lists plus:

Use of flying insect robots (sensor distribution, small sample collection, unique feature closeup examination)

Fully distributed bottoms-up microrobots (search for unusual materials, biomarkers, cell colonies, etc.)

Use of novel nanomaterials and sensitive skin (sensor design)

Use of direct brain current-controlled robots (EVAs, robotic sampling)

Software agents and decision theory

Self-reconfigurable robots and digital hormones

Role of robots (advanced time window)

Previous lists plus:

Molecular electronics

Fully autonomous robots for exploration, sensing, construction

Self-replicating, self-repairing robots

On-site sensor manufacture

Multiple sensor distribution and emplacement by robots

Full projected presence teleoperation

Robotic Requirements

- Robotic base preparation-autonomous and Earth-based teleoperations
- Science observers-sensor instrument integration (attached or distributed sensors)
- Assistants for human EVAs-fetch and carry, safety, field documentation
- Assistants for base support-monitoring, maintenance and repair
- Assistants for sample management and control-sorting of samples, labeling, documenting, storing
- Assistants for sample analysis-integrated to lab instruments and data systems

Technology Requirements

- Science observers and collectors-sensor instrument integration and data management, sample choosing, manipulation, trenching, digging, scraping, breaking, coring, carrying
- Robotic sample management and control-sorting of samples, labeling, documenting, storing, planetary protection
- Development of integrated robotic/human habitat laboratory with integrated sensors, instruments, data systems

Milestone Technology Demonstrations

- Earth-based
- Robotic field geologist/biologist-data acquisition with multiple sensors
- Feedback to activities and performance
- Sample acquisition – lifting, scooping, digging, coring, breaking, scraping
    - Rocks, soils, cores, gas, water
- Integrated sophisticated habitat module for sample analysis and sample sorting and documentation

Milestone Technology Demonstrations

- Lunar-based
  - Move successful Earth-based demonstration to Moon
  - Demonstrate field geologist/biologist operation
  - Demonstrate sample selection and collection
  - Demonstrate sample packing and return
- Mars-based
  - Insert technology into Mars missions when ready